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Spatial Harmonic Analysis of EEG Data

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Introduction

EEG is an important tool to investigate the function of the human brain. In this respect the potential distribution across the scalp is of particular interest. The high number of electrodes and high sampling rates in recent EEG systems require efficient spatial decomposition methods.

Methods

We present a new method for spatial harmonic analysis of EEG data using the eigenspace of the Laplace-Beltrami operator of the meshed surface of electrode positions. Several approaches to discretize the Laplace-Beltrami operator are examined. We apply the proposed method to data sets from EEG experiment addressing cortical activation related to somatosensory evoked potentials (SEP). The experiment employed an electrical stimulus of the nervus medianus according to IFCN standards using 256 EEG channels. The recorded EEG data are decomposed by projection in the space of the spatial harmonic basis functions.

Results

With the proposed method, basis functions of spatial harmonics for arbitrary arrangements of EEG electrodes can be successfully generated. In contrast to most multivariate decomposition methods such as PCA and ICA, the basis functions for the spatial decomposition are generated using only topological information of the electrode arrangement and the sensor positions. We show exemplary on EEG data sets of 12 volunteers that the main contribution to the recorded SEP data is provided by low frequency spatial basis functions. The discrimination of artefact-prone data-sections, such as ocular artefacts is possible.

Conclusion

The proposed method can be deployed to arbitrary electrode setups to estimate basis functions for a spatial harmonic decomposition. Both the spatial harmonic basic functions and the decomposition of the EEG data can be computed very efficiently. The approach can be used for the spatial harmonic analysis and filtering of EEG data and for artefact detection. Further applications, e.g., for MEG sensor systems are possible.